A CYLINDER-SAMPLER FOR COLLECTING THE INVERTEBRATE FAUNA FROM SUBMERGED AQUATIC VEGETATION

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ABSTRACT

A sampler designed to provide a quantitative estimate of the densities of the invertebrate fauna from littoral macrophyte zones of lakes from a small boat is described.

The sampler is a pole-mounted cylinder with rubber-powered stainless steel jaws at one end and a rotating sieve (at an angle of 45° to the long axis of the cylinder) at the other. Holes in the side wall of the sieve minimise the 'bow wave' of the sampler by providing through-flow for water as the sampler is lowered. The cylinder is attached to the pole by a hinge at its lower end so that the sieve is at the bottom when the sampler is raised, permitting freer drainage and minimizing clogging during sample collection. Sieve rotation (which closes off the four 'irrigation' holes), jaw release and the hinging of the cylinder are controlled by a single rope.

Data obtained during a survey of macroinvertebrate communities of the *Elodea canadensis* zone of Lake Grasmere, Canterbury, New Zealand, are used to determine the optimum number of replicate samples and to assess sampling variability.

INTRODUCTION

A wide range of methods and equipment has been devised for sampling invertebrates from aquatic macrophyte communities (Elliott & Tullett 1978). For quantitative studies, hand collections and hand-net methods are generally considered unsuitable (McCauley 1975), while sampling depth is severely limited with several other methods unless SCUBA is employed. Artificial macrophyte substrates (e.g. Macan & Kitching 1972, 1976, Soszka 1975, Macan 1977) are still relatively untried and must be tested against sampling of natural macrophyte communities to determine and account for their sources of error. The more

commonly used grabs, corers, and similar sampling devices also are not without problems. With many samplers, difficulty is experienced in separating the invertebrates on the macrophytes from those in the mud, there is often a pronounced 'edge effect', and the different growth forms and densities of macrophytes may adversely affect sampling reliability (Resh 1979). These considerations prompted the design of a cylindrical, pole-mounted sampler that could be operated from a small boat and sample down to four m depth.

THE SAMPLER

The sampler (Figs 1-4) is a pole-mounted cylinder (600 mm long x 100 mm internal diameter 'Alkathene' tubing) that can be closed at each end. Stainless steel jaws 2 mm thick (Fig. 2), one with a serrated edge, close with a strong rubber-strip-powered scissor action across the lower end of the cylinder to cut off and enclose the sample of vegetation and its macrofauna. The top of the sampler comprises a rotating sieve (200 µm mesh) set at an angle of 45° to the long axis of the cylinder. Four 20 mm-diameter holes in the side wall of the sieve provide through-flow for water as the sampler is lowered and can be closed off by rotation of the sieve. The cylinder is attached to an aluminium pole (2.2 m long x 15 mm internal diameter) by a hinge at its lower end and a sliding spring-loaded catch near its upper end. A further length of aluminium tubing (2 m long x 15 mm external diameter) when slid 200 mm inside the permanently attached pole and fastened with a bolt and wing-nut, enables samples to be obtained down to a lake depth of four m. The detachable pole has a brass adaptor that takes the thread of a standard hand-net ring, allowing it also to be used to collect non-quantitative samples with a hand-net. A strong nylon rope, running through brass eye-bolts attached to the aluminium poles, controls sieve rotation, jaw triggering and release of the cylinder from its upper fastening. The sampled area is 7.85×10^{-3} m^2.

The sampler is set in the following manner (Fig. 1):-

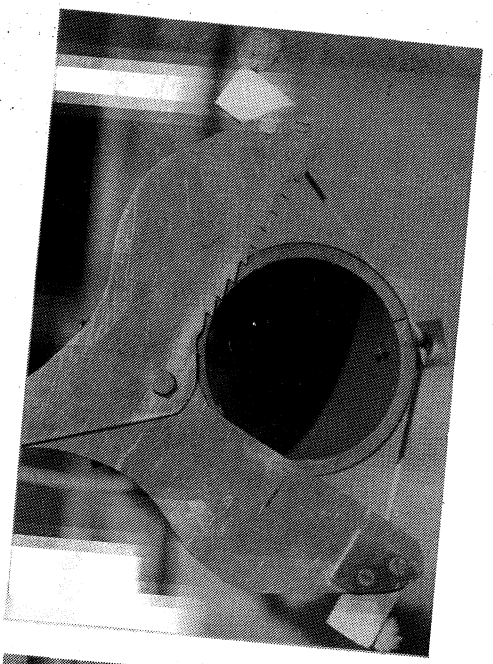
1. The top end of the cylinder is fastened to the pole by the spring-loaded catch.

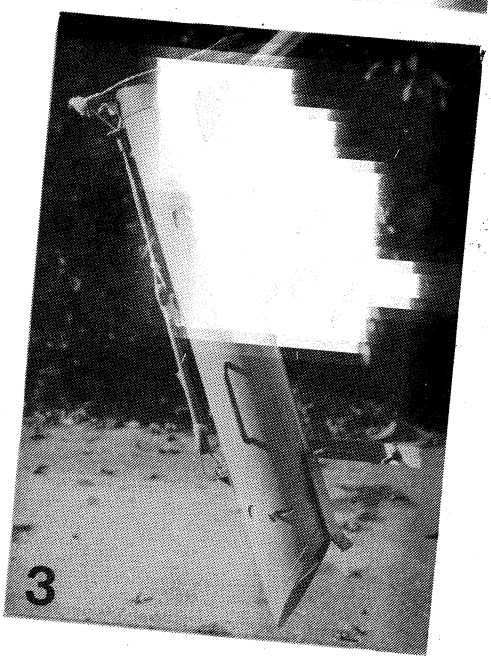
2. The jaws are held open by a brass clamp on the end of the triggering rope.

3. The sieve is rotated so that the four laterally-placed holes are open, and a rubber loop attached to the triggering rope is slipped over the end of the lever that controls sieve rotation. It is essential that the triggering rope is positioned as in Fig. 1 to facilitate smooth operation.

The sequence of operation is as follows:-

1. The sampler is allowed to descend over the macrophyte bed under its own weight. It was found that less variable replicate samples were obtained in this manner, rather





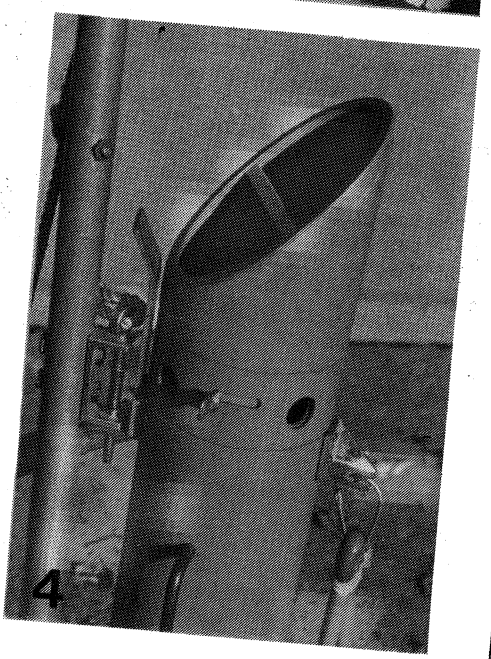


Fig. 1. General view of the sampler in the set position. Note: trigger rope with jaw clamp on lower end, rubber loop over end of sieve rotation lever, cylinder hinge release catch, and rubber "spring" arrangement (at left).

Fig. 2. Jaws, in the set position as seen from below.

Fig. 3. Sampler in the retrieval position.

Fig. 4. The sieve end with holes open and showing the locating bolt which retains the sieve.

than by delicate attempts, incorporating lateral movements, to position the sampler.

2. When the sampler reaches the substrate the triggering rope is pulled and the following three operations occur in sequence:-

   a. The sieve rotates to close off the four 'irrigation' holes,

   b. the jaws are released, cutting off and enclosing the sample, and

   c. the cylinder is released from its upper fastening.

3. The sampler is raised with the sieve end at the bottom and the water drains out (Fig. 3).

4. The sieve is removed by unscrewing a small locating bolt and the sample washed into a plastic bag. Once the sieve has been replaced the above sequence can be repeated for the next sample.

The sampler incorporates several design features that improve its efficiency. A significant error in quantitative sampling of aquatic macrophyte communities may arise from disturbance of macrophytes and invertebrates by the descending sampler. This was minimized and greater numbers of invertebrates collected when the sampler was allowed to descend under its own weight and when the "bow wave" was reduced due to the four 20 mm -diameter holes in the cylinder wall of the sieve. These holes are closed by operation of the trigger rope. This design reduced the visible disturbance to the macrophyte bed in the region of the descending sampler and, presumably, led to a reduction of the 'edge effect' (the unsystematic errors that influence measures of invertebrate density by, for example, the edge of the sampler brushing invertebrates from plant stems or causing those species with the most developed escape responses to flee, see Elliott 1977).

Mesh size of sampling equipment may influence markedly the estimation of population size, distribution and community structure (Malley & Reynolds 1979). The mesh must be fine enough to capture the smallest organisms required but not so fine that clogging becomes a problem. The final design of the sieve arrangement was the result of much experimentation. I found that if the sieve was placed at right angles to the long axis of the cylinder, clogging of the desired 200 µm mesh with fine sediment and filamentous algae became a serious problem when the sampler was used in the manner described above (i.e. the sieve at the bottom when the sampler is retrieved). A coarser mesh would have allowed too many smaller animals to escape. The solution was to incline the sieve at an angle of 45° to the long axis of the sampler so that any sediment or algae collected was washed to the bottom angle of the sieve leaving the greater part of the sieve clear for more efficient drainage. Also, this modification increased the filtering area relative to a circular sieve by about 40%.

The sampler was most effective in macrophyte beds where plant growth was upright. It was difficult to obtain samples where macrophyte stems were very short (i.e. less than 30 mm, e.g. *Isoetes alpinus* at certain times of year) or very long (i.e. greater than about 1 m, e.g. *Elodea canadensis* in deeper water) or from plant species whose growth forms were not relatively rigid or upright (e.g *Ranunculus fluitans* and *Potamogeton cheesemani).* At times of year when filamentous algal growth was extensive, difficulty was experienced in sampling. This was especially so in zones of *Elodea canadensis* where filamentous algae and macrophytes formed an almost impenetrable mat. In such conditions adequate quantitative samples are very difficult to obtain by any method.

DETERMINATION OF OPTIMUM SAMPLE SIZE

Sample size (number of replicates) chosen is usually a compromise between that which will provide an accurate representation of the community under investigation and the effort required for collection and processing. The sample size required for a given level of statistical precision in estimating number of species, relative abundance of invertebrates or total invertebrate biomass can be determined by analysis of the variability evident in a series of replicate samples.

To assess the efficiency of the sampler, eight sample units (where one unit is the product of one operation of the sampler) were taken on 14 April 1976 from a uniform *Elodea canadensis* zone at the northern end of Lake Grasmere (Grid Reference, NZMS1, S66, 244136), near Cass in inland Canterbury. The water depth in the region of sampling averaged about 1.5 m. Samples were placed separately in plastic bags and preserved with formalin. Macroinvertebrates were removed from the samples by sorting under a stereomicroscope at magnifications ranging from 6.3 X to 25 X. The numbers of invertebrates in each taxa were counted (Table 1).

Optimum sample size (i.e. the cumulative number of sampling units required) was determined by graphing numbers of taxa or numbers of individuals (e.g. of a species) collected against cumulative numbers of sampling units (Figs 5 and 6).

Cumulative numbers of taxa per sample derived from the original data (Table 1) are plotted in Fig. 5 (dashed line). Since the shape of this curve is influenced by the order in which sampling units are accumulated, especially when the number of replicates is low, random number tables (Snedecor & Cochran 1967) were used to rearrange the order of sampling unit accumulation. Thus Fig. 5 also shows the maximum, mean and minimum numbers of taxa per sample for the ten sets of data obtained. The mean number of taxa in one sampling unit (11.0) is fewer than, for example, the mean for six (18.1), but the variation between the minimum and maximum number of taxa for a single sampling unit was 28.5% compared to 10.5% when six sampling units were combined.

TABLE 1. NUMBERS OF INVERTEBRATES FOUND IN EACH OF EIGHT REPLICATE SAMPLING UNITS COLLECTED FROM THE *ELODEA CANADENSIS* ZONE AT THE NORTHERN END OF LAKE GRASMERE (14 APRIL 1976). P = PRESENT

Invertebrate group	Sampling units 1	2	3	4	5	6	7	8
Chlorohydra viridissima (Pallas)	3	10	24	0	0	0	1	6
Cura pinguis (Weiss)	0	2	1	1	0	1	8	1
Plumatella repens (Linnaeus)	P	P	P	P	P	0	P	P
Chaetogaster sp.	5	38	19	28	0	6	0	0
other OLIGOCHAETA	1	0	3	4	0	0	61	12
Glossiphonia sp.	0	0	0	0	1	0	1	0
CLADOCERA	0	45	17	8	62	7	28	27
OSTRACODA	0	0	0	0	0	0	2	0
COPEPODA	0	5	13	7	5	4	0	15
Xanthocnemis zealandica (McLachlan)	0	0	1	1	11	3	5	2
Antiporus strigosulus (Broun)	0	0	0	0	0	0	0	1
Paroxyethira hendersoni Mosely	1	0	2	21	13	10	12	1
pre-case HYDROPTILIDAE*	0	2	1	62	44	9	19	0
Nymphula nitens (Butler)	1	0	0	0	0	0	0	0
CHIRONOMIDAE	0	0	0	2	0	0	2	1
ACARINA	8	32	7	31	16	10	39	9
Gyraulus corinna (Gray)	138	367	292	219	88	45	288	51
Potamopyrgus antipodarum (Gray)	168	506	373	838	834	455	627	230
Sphaerium novaezealandiae Deshayes	1	0	0	0	0	0	0	0

*Hydroptilidae in the first four instars. Only the fifth instar, which inhabits a secreted case, can be identified.

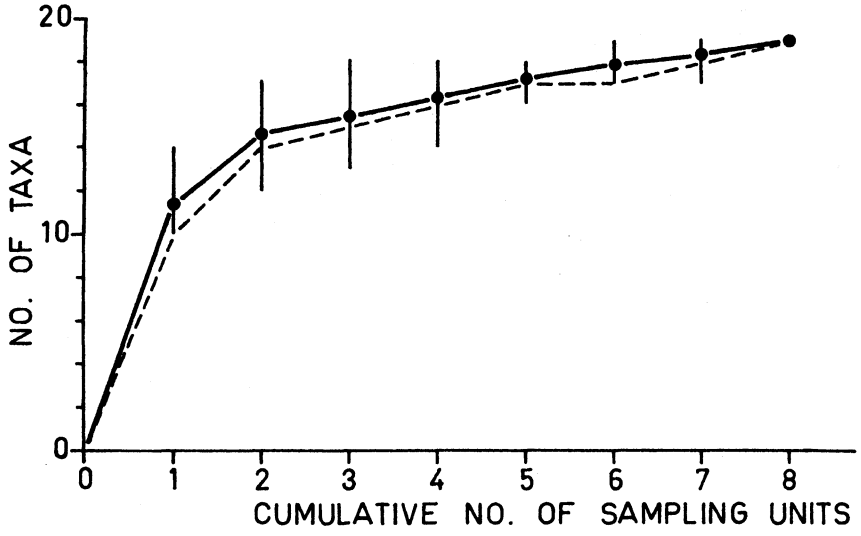


Fig. 5. Cumulative numbers of taxa plotted against number of sampling units; ----, cumulative numbers of taxa for one set of data in the order of collection; ———, cumulative mean numbers of taxa per sample for ten sets of data; vertical lines indicate maximum and minimum numbers of taxa per sample.

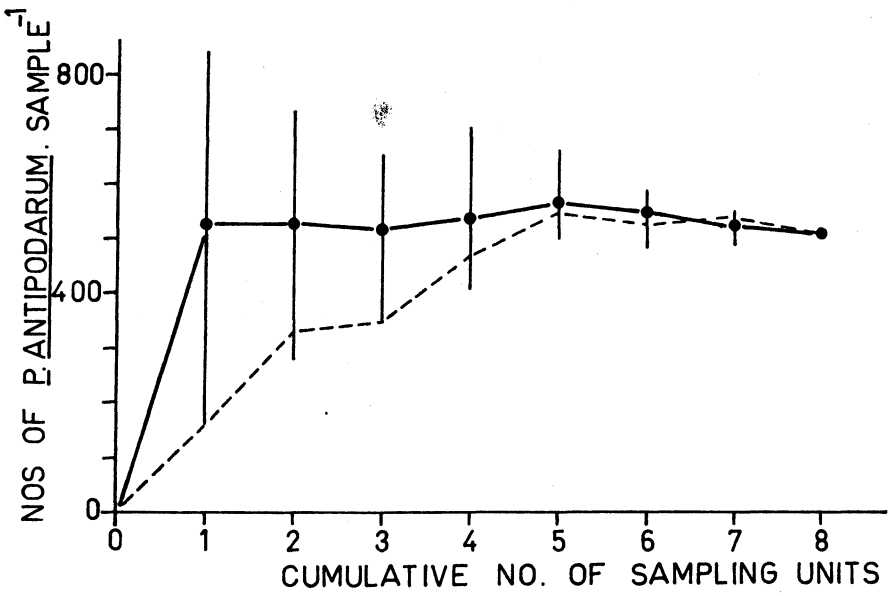


Fig. 6. Cumulative numbers of *Potamopyrgus antipodarum* plotted against number of sampling units; ----, cumulative numbers of *Potamopyrgus* for one set of data in order of collection; ———, cumulative mean numbers of *Potamopyrgus* per sample for ten sets of data; vertical lines indicate the range of numbers of *Potamopyrgus* per sample.

A maximum of 19 taxa, mostly species, was recorded from the eight sampling units (Table 1). As the cumulative number of sampling units increases, the accuracy of the estimation of the number of taxa improves (Fig. 5). Eventually, addition of sampling units adds no further taxa, i.e. the plot of number of taxa versus cumulative number of sampling units becomes asymptotic to the probable true number of taxa in the habitat. Extrapolation of Fig. 5 suggests that about 20 taxa were present in the *Elodea* zone at the northern end of Lake Grasmere in April 1976. With a sample size of four units (16.7% variation) a mean number of 16.3 taxa were recorded. This estimate is within 20% of the probable true number of taxa (20) in the habitat, a level of precision that is generally considered adequate in studies of aquatic communities (Elliott 1977).

Fig. 6 shows how the estimates of density of *Potamopyrgus antipodarum* (the most common macroinvertebrate in macrophyte zones of Lake Grasmere) are influenced by sample size. For this species, six samples were required to achieve the desired level of precision (within 20% of the mean), whereas five sampling units combined provided density estimates of ± 25% and a single sampling unit, ± 80% of the true mean density.

If a sample size of four sampling units (which represents a compromise between sampling effort and statistical accuracy) is chosen, the degree of similarity, in species composition, between samples using the percentage similarity of community index (PSc) (Whittaker & Fairbanks 1958) may be determined thus;

$$PSc = \Sigma \text{ minimum } (a, b)$$

where, for each species, a and b are, the percentages of samples A and B (each consisting of four sampling units) which that species represents. If two samples are totally dissimilar PSc = 0%, and if identical PSc = 100%. In the example the PSc value obtained is dependent upon how sampling units 1 to 8 (from Table 1) are divided into two samples, A and B, of four units each. Ten such samples of four units, each different combinations, were chosen with the aid of random number tables to test the effect of the composition of the samples of the PSc values. PSc values thus obtained ranged from 81.1% to 94.3% with a mean of 87.4% (standard error = 1.45%). This indicates a high degree of similarity between samples (of four units) in terms of species composition. Similar procedures can be applied to data collected from communities on different macrophytes, or to samples collected at different times of year to assess the consistency of sampling.

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